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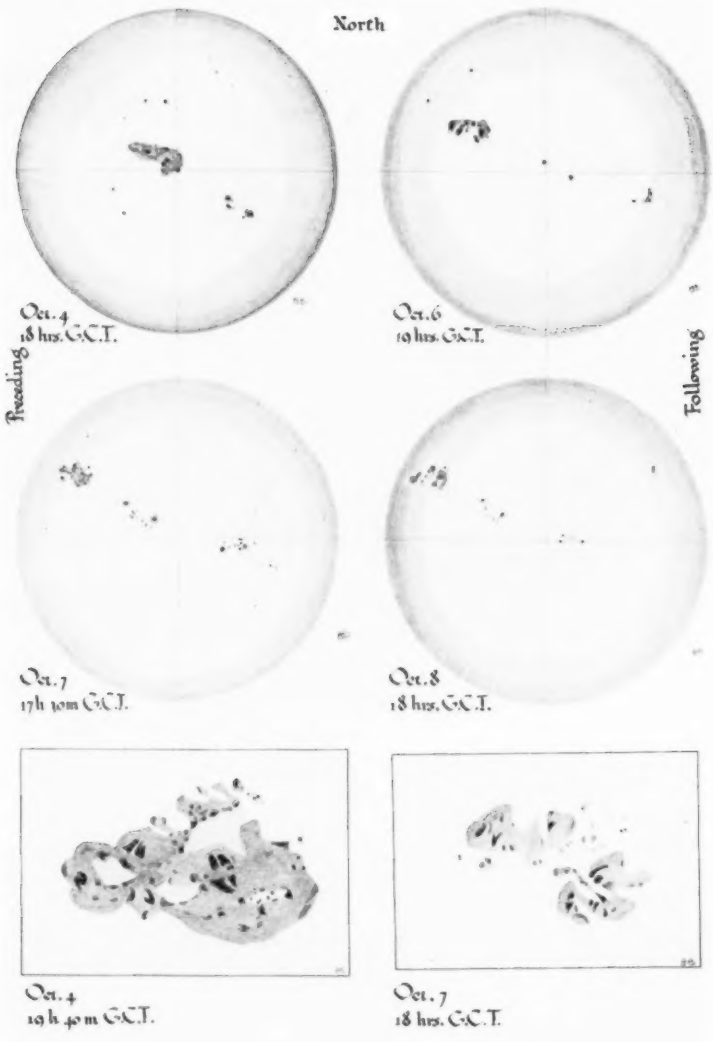

Sketches of Sunspots

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SKETCHING SUNSPOTS AT THE TELESCOPE

By H. BOYD BRYDON

(*With plate IX*)

AMONG the valuable hints on observing in that most excellent compendium of fact and advice to the young amateur in Norton's Star Atlas is this:—"All observations should be written down at the time when they are made. The notes should be clearly worded", etc.

In many cases, however, a single drawing is worth many hundreds of words. "Do not be discouraged by ignorance of drawing from attempting to represent what you see", says Webb in his Celestial Objects for Common Telescopes; "Everybody ought to be able to draw; it is an education of the eye and greatly increases its capacity and correctness; but even a rough sketch may have its use; taken on the spot and compared with the original, it will not be all untrue; it may secure something worth preserving and lead to further improvement."

Which is still true, even in this age of photography; for the eye, during a flash of good seeing, can see detail which escapes the most fortunately timed exposure of the photographic plate.

The drawings accompanying this paper illustrate observations made of the great disturbed area on the sun which appeared during early October. As they represent the first attempt by the writer to follow the Rev. T. W. Webb's advice and as the work was found of absorbing interest and may stimulate others to go and do likewise, possibly some notes upon the method employed may be of use.

The drawings of the sun's disk were made at the telescope. The detail drawings of the disturbed area were redrawn from sketches made at the telescope. The telescope is a 4-in. refractor and the full aperture was used during these observations. It is equatorially mounted and clock driven. The drive unfortunately has a bad periodic error, every revolution of the main worm causing the telescope to swing from side to side of the object. The result for such work even with low powers as described herein is a splendid exercise in the virtue of patience.

A good quality cartridge paper was used, pinned to a piece of thin 3-ply wood of convenient size, here 16 x 20 in., which was supported on a household step-ladder placed opposite the eyepiece and steadied by hand. The arrangement was found preferable in this particular case to the usual screen carried on rods attached to the telescope tube.

For the whole disc a 60 x eyepiece was used. Its field is just comfortably larger than the sun's image. A 6-in. circle was drawn on the paper and the support set so that the sun's image just filled it. With the driving clock stopped, a small spot was selected, brought to the first edge of the circle and a pencil dot made of its momentary position. Then, holding the drawing board stationary, the spot was allowed to drift across the circle, its position being marked at regular time intervals. A straight line drawn through these dots gave an east and west line. After the sketch was finished a line parallel to this one and another at right angles to it giving a north-south line were drawn through the centre of the circle.

The clock was now started, the image fitted to the circle by moving the telescope, not the drawing board, and at a convenient moment a dot was made fixing the position of a spot near one limb. By this time the image was beginning to drift out of the circle. When all was properly registered again, the sun to its circle and the dot to its spot by adjusting the position of the telescope and support, another spot near the other limb was dotted on the paper. Keeping these in register it was only necessary to continue the work until the drawing was finished. Every care must be taken to ensure that all points are correctly placed.

The 60 x eyepiece was then replaced by a 300 x; a fresh piece

of paper was pinned to the drawing board and the disturbed area carefully focussed, picking instants of best seeing for the close adjustment. The periodic error in the drive made it practically impossible to complete a sketch of this area by tracing on the paper the details of the image. The method adopted therefore was to fix two or three conspicuous reference points in the area by the method described above and, with the image thrown on the paper immediately above these positions to draw in the remainder free hand. It was a slow job but very interesting and a wonderful drill in self control.

The relative values of the lights and darks in the area were carefully indicated, the outline of the penumbral regions drawn and a faint hatching or shade laid in on the sketch to guide the subsequent work. These detailed sketches each required from an hour to an hour and a half to complete.

Do not try to draw too much; an artist does not draw the individual leaves of the trees in his landscape. Much that is far too delicate to be set down is seen during the moments of the best seeing but on such a sketch it is only possible to show the major detail as correctly placed and with as correct tonal values as one can. A B or BB pencil was found satisfactory. The size of the sketch is a matter of individual preference. The length of the disturbed area in the original drawings on October 4 and 7 is about 3½ inches.

For the finished wash drawing a reticule of lines spaced 5 to the inch was drawn over the original sketch and on the blank for the finished drawing. The outlines were then carefully and lightly transferred by free hand using a fine pointed soft pencil. Then with a No. 4 or 5 sable brush having a fine point the details of each sketch were gradually worked up, using repeated washes of greatly diluted india ink. The original sketch was kept before the eye and constantly referred to. It was found much more satisfactory to get the desired tones by repeated light washes than to put in a shade to the desired depth in one or two washes. The relative values were much more under control.

As a training for eye in observing and hand in recording, sketching at the telescope details of the sun's or moon's surface and the larger planets will be found of very great interest and a source of much enjoyment.

A last word: Do not let early failures discourage. Persevere. The necessary skill will be achieved much sooner than would at first seem possible. Also: be prepared for questions difficult to answer when your friends see your performances; "What is a sunspot?" for example.

Fifty years before the 4th edition of Webb's book was published (from which the above quotation was taken), the Council of the Royal Astronomical Society wrote (in 1828) "Everyone who possesses an instrument whose claims rise not even above a humble mediocrity has it in his power to chalk out for himself a useful and honourable line of occupation for leisure hours in which his labour shall be really valuable if duly registered." *If duly registered.*

Victoria, B.C.

COSMIC RADIATION*

By P. M. S. Blackett

THE study of cosmic radiation is rather a curious one. It is related ultimately both to astronomy, to geophysics and to physics. The subject started about 1900 with the discovery by C. T. R. Wilson, and by Elster and Geitel, that the air in a closed vessel had a slight residual conductivity. The apparatus used for these early experiments consisted of an ionisation chamber. A simple form of this apparatus consists in a metal box in which is suspended an insulated wire carrying a gold leaf; when charged electrically, the movement of this leaf records the electrical conductivity of the gas in the box. With such a simple apparatus as this it was found that there was a residual conductivity of the air, which could not be explained by the effects of the known radio-activity of the earth's crust, and which was probably due to the presence of some very penetrating radiation. In fact, C. T. R. Wilson himself, in 1901, speculated as to whether this residual ionisation might not be due to some radiation coming from sources outside the atmosphere, either electro-magnetic radiation, like X-rays, or corpuscular rays like cathode rays, but of enormously greater penetrating power. Since that time at least 1,000 researches have been made on the subject of cosmic rays and a great many facts have been found out. We know now that this residual ionisation is, in fact, due to atomic particles of enormous penetrating power coming into the earth's atmosphere from some sources outside the solar system, but exactly what these particles are, or where they come from, or how they were formed, or when, we still do not know.

In this lecture I am going to describe mainly the researches on cosmic rays which have been made with the ionisation chamber as the instrument for their detection. There are, in addition, two other

*Reprinted from the *Journal of the Royal Society of Arts* (London), Vol. 85, pp. 893-903. This is part of the first three lectures on Cosmic Radiation delivered in January, 1937, by Professor Blackett, of the University of London.

instruments by which these rays are detected and measured, which will not be discussed in this lecture.

Soon after the earliest experiments ionisation chambers were taken to different places on the earth to find out whether this residual ionisation varied from place to place. Then a great series of experiments began in which ionisation chambers were taken up mountains, in balloons, lowered down to the depths of the sea and carried in aeroplanes. The crucial experiments, which showed the cosmic nature of the rays, were those of Hess in 1911 and 1912, who took ionisation chambers to a height of 5,000 m. in balloons. Hess found that the ionisation due to the rays was larger at a great height than at sea level. This showed conclusively that the rays causing the ionisation must have come downwards from the top of the atmosphere, and not upwards from the earth; for if they had come upwards from the earth, they would decrease in intensity by absorption as one went up. Hess also found that the rays were equally intense both during the day and at night, and also during an eclipse of the sun. This showed that the rays could not come from the sun, because if they had, their intensity would be much less at night, or during an eclipse. Thus it was these experiments which led to the rays acquiring the name of "cosmic."

Since that time a very great number of experiments have been made to find out how the cosmic radiation varies in intensity in the atmosphere. Perhaps the most beautiful of these, and the most successful, have been the balloon flights of Regener and lately those of Millikan, who send very light recording apparatus up to great heights by means of small, hydrogen-filled rubber balloons. A small ionisation chamber, which is made to record automatically the intensity of the rays on a photographic plate, together with the barometric height and the temperature, is made to weigh only a few pounds. This is enclosed in a light frame covered with cellophane, which acts like an ordinary greenhouse; the sun's rays coming in through the cellophane get degraded into heat and cannot get out again. In this way the apparatus is kept warm at about room temperature, even though the temperature outside the apparatus is $-50°$ centigrade. The rubber balloons which are used to take the apparatus up have to be examined very carefully for small pin-holes, otherwise

they are apt to burst prematurely, before the desired height is reached. Professor Regener sometimes has to stop up 100 or so tiny holes with rubber solution before using a balloon. With such an apparatus heights of 30 km. above the surface of the earth have been reached, where the pressure of the atmosphere is only about 1 per cent. of that at sea level. It is found that the intensity of cosmic radiation is about 200 times as great as on the ground, confirming, of course, the view of Hess that wherever it is the rays come from it is at least outside the earth's atmosphere.

With similar, but much larger apparatus, the ionisation due to cosmic radiation has been studied under water, down to great depths. Regener, again, has measured the ionisation down to depths of 280 m. below the surface of Lake Constance, and finds that their intensity is only about 1 per cent. of that at sea level. So from the bottom of Lake Constance to the top of the stratosphere the intensity of cosmic rays increases by a facor of over 10,000 to 1. The enormous penetration of the rays, a penetration quite unexpected in the region of atomic physics, leads naturally to the conclusion that the rays must be of immense energy. The most penetrating atomic rays previously known, the gamma rays from radium, can only penetrate a few metres of water. Thus, the cosmic radiation is many hundred times more penetrating, and is therefore likely to be very much more energetic. In fact, it can be easily estimated that, to explain the very great penetrating power of some of the rays, it is necessary to assume energies up to 10^{11} electron volts.

The next great series of experiments consisted in the carrying of ionisation chambers all over the world. Expeditions to the equator, to near the north magnetic pole, expeditions on mountains and in ships, all these have been used to find out how the intensity of cosmic radiation varies with the latitude and longitude and the height of the place of observation. This aspect of the study of cosmic rays can be called the geophysical aspect and is, in fact, closely related to the study of the variation of the earth's magnetic field over the surface of the earth. Lines of equal cosmic ray intensity—or isocosmic lines, as they are called—run very nearly parallel to the lines of equal geomagnetic latitude. They also run nearly parallel to the lines of equal auroral frequency. The explanation of this relation will be mainly left to another lecture, but can be given shortly by saying that the cosmic rays as they reach the upper levels of the earth's atmosphere

are mainly electrically charged particles of very great energy. These particles are deflected by the magnetic field of the earth so as to reach regions of higher latitude more easily than regions near the equator. This behaviour is very similar to that of the charged electrical particles which are held to be the origin of the Northern Lights. In fact, the theory of the *aurora polaris*, proposed many years ago by Birkeland and Störmer, applies almost unchanged to

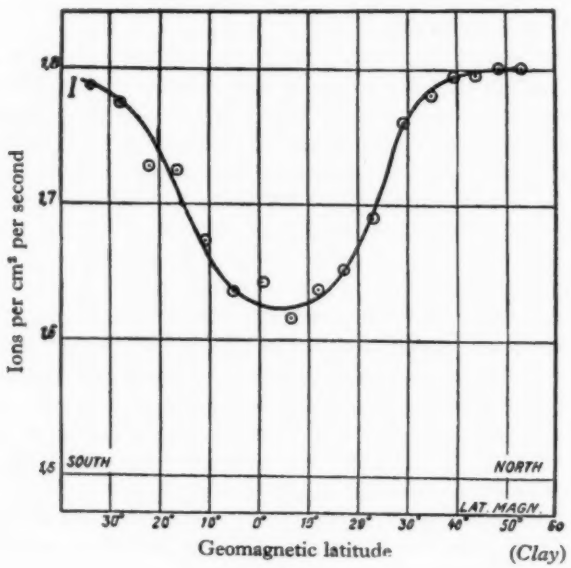

Fig. 1

cosmic radiation. The intensity of cosmic radiation is found to be nearly constant from latitude 50° north up to the poles, but decreases towards the magnetic equator, the decrease amounting to about 15 per cent. Fig. 1 shows the results obtained during a voyage from Southampton to Cape Town. At greater heights, the increase from the equator to the poles is much greater.

This study of the intensity of cosmic radiation at great heights and in different latitudes is of the highest importance, but our knowledge

is at present extremely fragmentary and quite inadequate for many purposes. In order to test theories as to the nature and behaviour of the rays, we really want to know the intensity of the cosmic radiation from sea level right to the top of the atmosphere at all latitudes, but so far it has not been possible to do many experiments of this type.

Apart from the free balloon ascents by the technique already described, valuable results have been obtained by the use of manned balloons. This technique was first developed by Professor Piccard. It is well known that it is not possible to live at a height above, say, 20,000 feet, without the use of oxygen—at least, if one cannot spend a long time acclimatising oneself to the reduced pressure. One can go to a height of 40,000 feet or so if one breathes oxygen instead of air, but one cannot go very much higher, even breathing pure oxygen, unless one keeps up the pressure of the body artificially. There are two ways of doing this: one can place oneself, as did Professor Piccard, in a metal gondola, generally of spherical shape, which is sealed up and retains the pressure on the body above that of the air outside. The other method is to use a pressure suit, that is a suit rather like a diver's suit, but in which the pressure is kept above that of the atmosphere. This method was used in setting up the recent altitude record for aeroplanes. With the former method Piccard and his collaborators and also some other investigators in America have reached heights up to 18 km., carrying elaborate and heavy apparatus with them. In one such flight from Belgium, which ended up somewhere in Central Europe, Dr. Cosyns measured the variation of the intensity of cosmic rays as he floated across Europe at a height of some 12 km. He found, much to his surprise, that the cosmic radiation remained constant from about 51° north to about 49° north, and then dropped suddenly as he went further away from the poles. This critical latitude of 49° north, above which the cosmic radiation remains constant, is of great importance in all cosmic ray theory. We have to try and explain exactly why the cosmic rays remain constant north of this latitude both at sea level and at great heights. At present there is no satisfactory explanation of these facts.

The next part of the study of cosmic radiation to be described is how the intensity varies with the time. Experiments have been

made over periods of years to see if the cosmic radiation is quite constant or if, and how, it varies. Some results are shown in Fig. 2. The soft components of radiation, that is the part of the radiation which has not a very great penetrating power, does show an appreciable variation with the time of day. There is a slight maximum

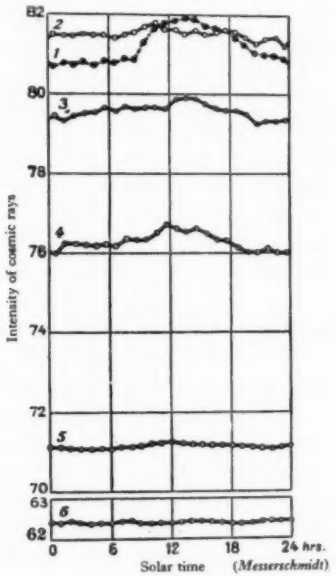

Fig. 2

1. No absorber
2. Absorber 0.5 cm. Pb.
3. Absorber 1.5 cm. Pb.
4. Absorber 3 cm. Pb.
5. Absorber 10 cm. Pb.
6. Absorber 20 cm. Pb.

about mid-day of the order of a few per cent. of the whole intensity. But when the soft radiation is filtered out by means of thick lead screens, the remaining penetrating component is found to be almost constant. The figure shows that this penetrating component does not vary more than a fraction of 1 per cent. throughout the day—that is,

when the results are averaged over a very large number of days. This again shows, as did the early experiments of Hess, that the radiation cannot come from the sun—at least, if it travels in straight lines—for if it came from the sun it would be very much more intense by day than by night. One can, in fact, conclude from the constancy of the radiation with time that the rays, as they reach the earth, must be isotropic—that is, they must be coming from all directions equally; for if they were coming from any one direction predominantly, then since the earth is rotating, any part of the earth's surface would receive more radiation when it was facing the direction from which more rays were coming. Thus, the constancy in time of the rays implies their isotropy in space. Now this is one of the most difficult things to explain about the cosmic rays, for it is very difficult to find plausible sources for the rays which are uniformly distributed with regard to the earth. As has been mentioned already, the sun is obviously excluded as a possible origin, but so also are the stars of our galactic system, for these are far from being uniformly distributed round the earth. If one looks at the night sky one sees a great concentration of stars which we call the Milky Way. There are many times more stars in this direction than in a direction at right-angles, so if the rays came from the stars of the Milky Way there would be a greater intensity of the rays when the Milky Way is overhead. This means that the rays would show a variation with sidereal time, but careful investigations have shown that there is very little variation indeed. There is a small effect, which will be discussed later, which is of great importance and which has only recently been detected, but the variation with sidereal time is very much less than would be expected if the stars of the Milky Way were the origin of the rays.

Now all the stars that one sees with the naked eye, or can be seen even with a large telescope, are members of a huge group of stars called the galactic system. This system contains some thirty-thousand-million stars. These stars form a kind of huge flattened disc, of which the size can be roughly estimated as being sixty thousand light years in diameter and five thousand light years thick. It may be noted that a light year, which is the unit of distance often used by astronomers, is the distance travelled by a ray of light in a

year, and is about 10^{13} km. About 90 per cent. of the matter in the galactic system lies in this central flattened disc, about half consisting of stars and about half of diffuse matter and of gas. The earth is situated somewhere near the central plane of the disc, but about twenty thousand light years from its centre. This whole galactic system constitutes a huge nebula analogous to, but probably rather larger than, the great spiral nebula in Andromeda. There is a great central condensation of stars near its centre which lies towards the constellation of Sagittarius, this constellation lying in about the thickest part of the Milky Way. In recent years it has been discovered that the whole galactic system is in rotation, making one complete revolution in about two hundred and fifty million years. Since the earth lies so far from the centre, it is travelling through space with a very large velocity, amounting approximately to about 300 km. per second. It can be shown that the effect of this large velocity is to make the intensity of cosmic radiation slightly greater on the side of the earth which faces the direction of motion, as compared with the opposite side. Just in the same way as more raindrops are found on the windscreen of a moving car than on the back window, so the motion of the earth is revealed by the greater intensity of cosmic rays on one side. This fact was predicted by Compton, and has been recently found experimentally. The variation is quite small, being less than 1 per cent. in magnitude, but it seems fairly clear from the measurements of Hess and Steinmaurer Schonland and of Kohlhörster, that the predicted variation does really exist. This is a very important result, for it confirms the view, that I have mentioned above, that the cosmic radiation cannot have its origin in our own galaxy. Fig. 3 shows the results of the variation with sidereal time which confirm Compton's predictions.

It is of interest to note that if the earth had been completely covered with cloud so that no stars could ever have been seen, it would still have been possible to show that the earth was moving very rapidly towards a certain direction in the heavens, or, more accurately, moving relative to something, the only property of the something being the power of producing cosmic rays. We will take it, therefore, that it is experimentally demonstrated that the cosmic rays are of extra-galactic origin.

We must, therefore, seek for some extra-galactic origin for the rays which is uniformly distributed all round the earth. Now there are such bodies—in fact, the whole universe is filled with nebulæ—and these nebulæ are, in fact, nearly uniformly distributed around us. Each nebula may be considered to be another galaxy similar in principle to our own, but in general of rather smaller size. But if we imagine that these nebulæ are the origin of the cosmic rays, we meet with a great difficulty, for it has been shown that the rays do not come from our own galaxy, so why should they come from any

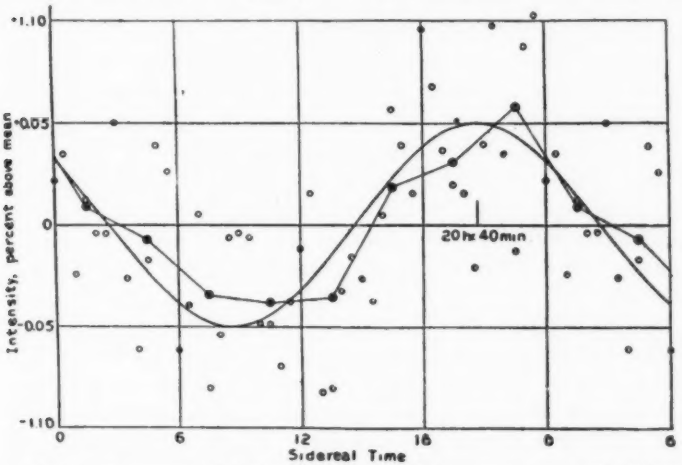

Fig. 3.—Percentage variation in intensity of the cosmic rays with sidereal time. Curve, predicted effect due to galactic rotation. Data, Hess and Steinmaurer; open circles, half-hour means; solid circles, 3-hour means (*Compton*).

other galaxy? These nebulæ are of widely different types, but it seems probable that these different forms represent mainly different stages in very similar life histories. The youngest nebulæ seem to consist of a great mass of diffuse gas which gradually condenses into stars, and develops finally, in many cases, into a spiral form such as is shown by the great nebula of Andromeda. Our galaxy is probably a nebula of this last type. Thus, it is, of course, possible that the cosmic rays are produced by nebulæ in the early stages of their existence, but not in the later stages such as our galaxy is in now.

There is another reason why the cosmic rays are unlikely to be produced by the stars in ordinary nebulæ. This is the fact that the outside layers of nearly all stars are rather similar. These outside layers consist of a gaseous envelope at a temperature of, say, between 5,000 and 20,000 degrees centigrade. Now since we know that the sun does not produce cosmic rays, it is difficult to see why other stars, which have rather similar surface conditions, should do so. There are exceptions to this general similarity of the outside of the stars. The White Dwarfs are very small but very dense stars, and have surface conditions which are very different from that of our sun, and so might conceivably be considered possible origins for the rays. It must be remembered that cosmic rays, although very penetrating from our terrestrial standpoint in that they can penetrate some thousand metres of water, cannot be considered penetrating from the point of view of a stellar atmosphere. Any cosmic ray which was produced inside a star would never get out. It is thus clear that it is only from the outer layers of a star that the rays could come, and these outer layers are nearly all alike.

Many other possible explanations of the origin of the rays have been given, but none put forward hitherto seem very plausible. It is possible, of course, that the rays have their origin in electric fields in extra-galactic space, but there is no real reason to believe that such fields exist, and it is difficult, perhaps, to explain on this basis the isotropy of the rays. Then, Swann has suggested that they have their origin in sun-spots—not sun-spots in the sun, of course, but postulated spots in giant stars.

Milne has predicted the existence of rays of very great energy from his cosmological theory. This theory requires also the existence of uncharged particles as well as electrically-charged particles.

Zwicky and Baade have sought the origin of the rays in the super-novæ, that once every few hundred years appear in every nebula and grow to huge intensity for a period of a few weeks. Another class of suggested origins are the archæological hypotheses. The arguments in favour of these views are roughly as follows. It is very hard to find an origin here and now in the universe for the cosmic rays, so perhaps they were formed at the very beginning of time when the world was quite young and, supposedly, very different. It is, of

course, obvious that if they have come from a very great distance that they must have their origin in the distant past. Lemaitre is an exponent of one of these theories. He supposes that the rays have their origin in some kind of super-radioactive process from a single primæval nucleus, from which has developed the universe as we know it now; but, as there does not seem to be any possibility as yet of testing or distinguishing between these numerous rival hypotheses, it is probably not worth while spending very much time on such speculation. One more ingenious origin may, however, be mentioned. It has been suggested by Alfvén that the rays arise from a kind of stellar cyclotron formed by the rotation of a double star. It is supposed that the combination of an electric field of one component of the double star, together with its magnetic field, may lead to the possibility of stable orbits for high-speed electrons very similar in principle to the orbits in the cyclotron of Lawrence; but here again no definite test of this hypothesis is possible.

SCIENCE AND TECHNOLOGY[1]

By Ernest O. Lawrence

IT is appropriate on this occasion to draw your attention again to the great partnership of modern times—science and technology; for the mutual independence of the pure and applied sciences in the development of our material welfare is nothing short of an absorbing romance.

The applied sciences are devoted to perfecting instruments and means already available, a procedure which in some quarters has been regarded as the best attack on practical problems. On the other hand, the pure scientist is guided by curiosity to learn more about the facts of nature—and it frequently has turned out that new knowledge thus gained has furnished the basis for doing something in a way incomparably better than any perfection of the methods that were already in use.

The following is an illustration: A hundred years ago if one had wanted to improve artificial illumination the direct practical procedure would have been to improve the candle or the oil lamp, and worthwhile progress could certainly have been made in this direction; but researchers in electricity, who studied the subject at that time entirely without regard to its practical application, furnished the basis for new means of lighting which turned out to be vastly superior to anything that could have been obtained by the further perfection of the old sources. It was then that Michael Faraday discovered that a current can be generated in a wire by a changing magnetic field. You all know how, from the tiny galvanometer deflection which first showed Faraday the principle of electromagnetic induction, there developed for the use and comfort of mankind the electric generator, the electric light and the hosts of modern inventions which have followed in their wake.

It is remarkable that Faraday, the man of science so devoted to

[1]Commencement address by Professor Lawrence, of the University of California, at the Stevens Institute of Technology, on June 12, 1937. Reprinted from *Science*, Vol. 86, pp. 296-298.

the patient search for the underlying principles of electricity, possessed at the same time a vivid appreciation of the practical implications of scientific discoveries. Gladstone, you will remember, on seeing one of Faraday's famous experiments terminate in an effect which to the non-scientific mind was very uninspiring, asked what possible use his discovery could be. "Why, Mr. Prime Minister," answered Faraday, "you will soon be able to tax it." On another occasion in reply to a similar question from an elderly lady, he quoted Benjamin Franklin, "Madam, of what use is a new-born child?"—a remark full of significance.

It might be argued that one should devote himself only to those subjects that can be immediately applied; but the development of some entirely new branch of science may give a means of benefiting humanity which could not have been foreseen had one been guided solely by practical considerations. Again let us take a hypothetical illustration. Suppose that in the nineties a surgeon had set himself the task of improving the methods of diagnosing and setting bone fractures. He would not have known that the greatest contribution to that problem—the discovery of X-rays—was soon to come from the quiet baloratory of a man curious about electrical phenomena in a vacuum tube.

Roentgen's discovery, closely followed by Becquerel's recognition of radioactivity, provide two of the prominent milestones of science. The benefits that have already been given to mankind through their application to medicine are familiar to all, but they were of much greater significance than in respect to their practical aspects alone. When these startling discoveries were made physical science was drifting in the doldrums. There was a wide-spread feeling that the great underlying laws of nature were fully comprehended and that the scientific developments of the future would be concerned with less interesting and important details. Michelson had just made his whimsical prognostication that the future of physics lies in the next decimal place, implying a not too exciting or brilliant prospect. But the discovery of X-rays and radioactivity abruptly altered all this by reviving science, and at the same time the proper humility of scientists.

These epoch-making discoveries suddenly disclosed a new world —the world of the atom. The chemist's conception of the atom as

an indivisible entity was soon discarded and in its place came wide recognition that within the atom lie domains of inconceivable richness. It is needless to elaborate on the great strides made by atomic physics in the intervening years. The man in the street now knows that his radio is operated by innumerable tiny slaves called electrons; and over his radio comes information on other miracles of technological science which have to do with the scintillating world of atoms. This is only to remind you that all these things came in the wake of Roentgen's chance discovery.

Again history has repeated itself—there are scientific cycles just as there are business cycles. Thirty years after the discovery of x-rays, the atomic theory had acquired an unwarranted position. The great successes of the theory gave rise to a wide-spread feeling that scientists really understood the underlying principles of the atomic world and again that the future held forth only the unexciting prospect of elaborating the details. The arrogance and complacency of the atomic physicist of the last decade was a perfect repetition of the attitude of the classical physicists at the end of the last century.

This state of affairs was short-lived, for now we are on the threshold of a new era fraught with potentialities for the future, as in the days of Faraday and of Roentgen—the era of the atomic nucleus. The new frontier lies within the hearts of atoms, and we are in a position to attack the problem the ancient alchemists set for themselves. Indeed their dreams have already been surpassed, for they sought ways of turning base metal into gold, while the modern scientist is now making something vastly more precious and useful, the artificial radioactive substances. It is not possible here to adequately tell the exciting story of artificial radioactivity and the important contributions to medical science that are in prospect or to tell about those swiftly moving fragments of atoms, the neutron rays, that are often the result of explosions within the atomic nucleus, and which are more penetrating than X-rays and indeed are already known to have more interesting properties.

Even to give you a survey of the many advances in the domain of the atomic nucleus would exceed the limits of your patience, and I shall restrict myself to the discussion of one significant result that

has recently emerged—the experimental proof of the equivalence of mass and energy.

One of the consequences of Einstein's theory of relativity, first enunciated in 1905, was that matter is one form of energy. This consequence of relativity that it might be possible to release energy by the annihilation of matter or that matter might be created by the absorption of energy was no more revolutionary than the fundamental postulates of the relativity theory, yet it rocked the very foundations of physical thought—for we all had been brought up on the principles of the conservation of energy and the indestructibility of matter.

As the Einstein theory grew in favour, the validity of the mass-energy relation became more apparent, but until direct experimental verification was forthcoming, Einstein's great deduction could not be regarded as an established law of nature. Cockcroft and Walton, of the Cavendish Laboratory, in their pioneering experiments about five years ago on the transmutation of lithium were the first to observe beyond any question the conversion of matter into energy. Subsequently, studies of many other examples of transformation of the elements have given an abundance of additional evidence and there is no longer any doubt about the truth of this principle.

Now that it is an established fact that matter can be converted into energy, let us consider for a moment what this means. At the outset one is impressed with the tremendous amount of energy tied up in the form of matter. For example, a simple calculation according to the relativity theory shows that a glass of water if completely destroyed and converted into useful energy would yield more than a billion kilowatt hours, enough energy to supply a city with light and power for quite a time. It is a highly practical question therefore to inquire whether it is possible to tap this inexhaustible supply of fuel.

The source of the sun's energy has long been a great mystery, for there is good evidence that it has been blazing at its present brilliance for billions of years, and as yet there is no sign of its going out. Fuel for this almost eternal fire could be of no ordinary sort; and astronomers and physicists now believe that conditions within the sun are such that nuclear reactions are taking place on an extensive scale with the destruction of matter and conversion into radiant

energy. Thus, the sun is gradually through the ages losing its mass; slowly its very substance is radiating into space.

But whether it will be possible to release subatomic energy on a practical and profitable basis for industrial purposes, whether perhaps it will be possible to realize conditions on the earth similar to those in the sun, is the question which of course interests the engineer. Indeed, it is a question of interest to everyone, and accordingly it has been the subject of much popular discussion and speculation. But speculation is hardly more than a game of fortune-telling, and this is out of place here. It is only of interest to indicate the present state of knowledge with proper humility, with recognition that what the future holds forth only the future can tell. In this spirit it may be said at this time that although we now know that matter can be converted into energy, there is no greater prospect of destroying nuclear matter for power purposes than of cooling the ocean to freezing temperatures and extracting the heat for profitable work. Certain considerations bearing on the second law of thermodynamics would appear to govern the availability of energy in the hearts of atoms as in the Atlantic Ocean itself.

While the view that some day power plants may be run by the release of subatomic energy and that nuclei of atoms may be used as fuel appears fantastic, nevertheless, proof of the equivalence of mass and energy is none the less of great practical importance. It is conceivable that in our lifetime this great principle will play a vital rôle in technical developments which at the moment are beyond our dreams—for such has been the history of science.

Thus far the essential rôle played by pure science in industrial development has been dwelt upon with the endeavour to bring into relief the fact that much of our technological progress can only be achieved by the methods of the investigator whose primary interest is that of unravelling the mysteries of nature—following the threads of logic and experimental revelation wherever they lead without restriction of practical goals. But to stop here would be giving only one side of the picture; for technology is just as important for science as science is for technology.

In making this assertion the thought in mind is not that in the long run the practical achievements of industrial science are respons-

ible for the prosecution of pure science, although it is true in large measure. Rather it is that industrial developments, per se, have been of essential importance in scientific progress.

Two famous experiments, one devised by Galileo three centuries ago and the other in modern times by Michelson with the aid of his interferometer, illustrate the point. Galileo dropped heavy bodies from the top of the leaning tower of Pisa and demonstrated that those of different weights fall to the ground in the same time. As regards experimental skill and delicacy of apparatus, this experiment could have been made many centuries earlier. Moreover, the ideas involved merely concerned weight and speed of travel, ideas familiar to people of ancient times.

But Michelson's' experiment could not have been made earlier than it was. It required the general advance of technology as well as Michelson's experimental genius. It concerns the earth's motion through the ether, the all-pervading medium of light waves. Michelson's ingenious apparatus required the finest of optical parts, the products of the contemporary optical glass workers. Accordingly, it may be said that the perfection of glass technology made possible the Michelson interferometer, which in turn resulted in an experiment that formed the basis of Einstein's theory, a theory which has revolutionized not only our understanding of physics, but also our entire philosophy! Indeed, two philosophers, Alfred Whitehead and Victor Lenzen, provided these illustrations which I have borrowed.

And so leaving in your minds the essential rôle of pure science in modern technological progress and the equal importance of modern technology for the advance of science, I shall close, acknowledging my obligation to these modern philosophers by quoting from one who was a contemporary of Galileo—for it was Sir Francis Bacon who said, "Nature to be commanded must first be obeyed. Knowledge is power."

METEOR NEWS

Observations relating to meteors and meteorites are cordially invited.

Observations of Two Spring Meteor Showers

For some years now Mr. Jack Grant of Orillia, Ont., has been carrying out a consistent programme of meteor photography on nights near the maxima of well-known showers. He uses an F/1.9, 25-mm. focal length, movie lens as well as some slower cameras and has had considerable success in securing direct photographs of meteors. Visual observations are carried out along with the photographic when time can be spared from running the cameras.

Mr. Grant made observations at the time of the Lyrid and Eta Aquarid showers last spring, the details of these programmes being tabulated below. The only lens used was the F/1.9 and no meteor photographs were secured. Owing to the presence of the moon and some clouds the weather conditions were far from perfect on any of the nights listed.

Lyrid and Eta Aquarid Observations—1937

Date	E.S.T.	Total Time Observed	Weather Factor	Shower Meteors	Sporadic Meteors
Visual Observations					
Apr. 19-20	10.20-12.00	0.8 (hrs.)	5	0	2
Apr. 19-20	12.00- 2.10	1.1	5	3	4
May 5-6	2.50- 3.50	0.4	7	0	1
Photographic Observations					
Apr. 19-20	10.20- 2.20	3.6		—	—
May 3-4	3.40- 4.10	0.2		—	—
May 5-6	2.10- 3.40	1.2		—	—

A Meteor Train of Twenty Minutes' Duration

The report of an interesting meteor train has been received from Mr. Louis Koenigsberg, Jr., of Buffalo. Mr. Koenigsberg made the observation from St. Louis, Mo., and the writer has communicated with other meteor observers in that part of the country but so far has been unable to locate anyone else who observed this object.

The meteor appeared at $23^h\ 30^m\ 52^s$ C.S.T., on August 17, 1937,

and was of a brilliant green colour, the magnitude being given as 0. There were two bursts along the trail after each of which showers of sparks were given off. The last burst was recorded as audible. The meteor was a Non-Perseid, passing through the centre of Cassiopeia from the direction of M 31, the visual path being 19 degrees in length. The train remained visible for 20 minutes and was carefully plotted by Mr. Koenigsberg on a Perseid map. The observed drift in horizontal co-ordinates during this time was roughly 26 degrees, the direction of motion being south and a little west. Since no second observation of this train is available an accurate determination of the velocity of drift is impossible. If, however, we assume the train to have appeared at the average height of 55 miles then the observed angular drift of 26 degrees in 20 minutes gives us the value of 100 miles an hour as the minimum possible true velocity of the persistent train. This is yet another confirmation of the fact that at heights where meteors commonly appear air currents of high velocity are the general rule rather than the exception.

P. M. M.

REVIEW OF PUBLICATIONS

Der deutsche Kalender des Johannes Regiomontan. Nürnberg um 1474. Facsimile 1937. Leipzig: Harrassowitz.

One of the ablest astronomers just preceding Copernicus was Regiomontanus. His real name was Johannes Müller and he was born June 6, 1436, at Königsberg, which when latinized became Regiomontanus. At eleven he was at the University of Leipzig and at fourteen he went to the University of Vienna where Purbach was professor. Even at twelve he had busied himself with the calculation of planetary orbits. In 1461 he went to Italy to study the "Almagest." He returned in 1468 to Vienna but soon afterward went to Nuremberg, then one of the most flourishing cities of Germany, where one of the early printing presses had been established. He was received with great honour and was given much assistance in carrying out his projects. To meet the special requirements of astronomy he set up a printing press of his own, and from it, among other publications, he issued (1) a succession of almanacs which gave the public general information about church feast-days, phases of the moon, eclipses, etc.; and (2) more advanced volumes of ephemerides giving further detailed and technical data. It is said that Columbus probably used one of these volumes on his first voyage to America. In 1475 Regiomontanus was invited to Rome to assist in the reform of the calendar. He died there the next year at the early age of forty. Copernicus was born in 1473.

There are few of the calendars of Regiomontanus in existence, two of them being in the British Museum. The one used for the present facsimile is in the Prussian State Library. The original volumes were printed with great skill and in good taste, and the reproduction is excellently done. The calendar occupies sixty pages and the scholarly introduction and explanation by Dr. Ernst Zinner of the Remeis Observatory at Bamberg in Bavaria runs to thirteen pages.

C.A.C.

NOTES AND QUERIES

Communications are invited, especially from amateurs. The Editor will try to secure answers to queries.

Notes from the Dominion Astrophysical Observatory, Victoria, B.C.

In continuance of the observing statistics from the September issue of the Journal we have the following:

1937	Nights	Hours	18-year average Nights	Hours
July	19	101	23	128
August	18	130	24	150
September	21	147	20	152

It is thus seen that the observing weather has been considerably below the average. However, with fresh coats of silver on both primary and secondary mirrors in the middle of July a goodly number of satisfactory spectra were obtained. With the announcement of two supernovae, one in Canes Venatici and the other in Perseus in September, an effort was made to obtain spectra of these faint objects. The former, though quite far west, was successfully spectrographed with a dispersion of 90 angstroms per millimetre, but due to cloudy weather the Perseus supernova was not obtained until early October when it had faded to 13^m and the slitless spectrograph with a dispersion of 140 angstroms per millimetre was used. Spectra of other old novae were also obtained at the same time.

An aluminizing equipment for the secondary mirrors is under construction. The bell jar and bed plate have been built and set up. A couple of vacuum pumps have been secured and Dr. McKellar, who has had considerable experience in vacuum work, is taking the lead in getting the equipment in working order. Several accessories are still needed, but it is hoped to have the apparatus complete in the course of a few months.

An exceptionally large group of sun spots passed almost centrally over the sun's disk around the 3rd of October and on the evening of that day a beautiful display of the Northern Lights was visible.

Dr. R. M. Petrie and Mrs. Petrie returned from their eastern trip towards the end of September. Dr. Petrie was representing the

observatory at the meeting of the American Astronomical Society at Williamstown in early September. He visited the observatory at Ann Arbor and spent a couple of days also at the McMath Solar Observatory at Lake Angelus and speaks very highly of the equipment there. He was privileged to assist in the aluminizing process of some of the mirrors while there. On his return he also visited the Yerkes Observatory. He travelled 7,000 miles by auto and several hundred more by train.

Visitors to the observatory of recent date include Professor B. Edlén of Upsala, Sweden, who gave us an interesting seminar on his researches on the spectra of the ionized atoms of the lighter elements. He told us, too, of their success in ruling gratings, particularly suited to their needs.

Dr. Frank H. Spedding, who has been appointed head of the department of physical chemistry of the State College of Iowa, also paid a short visit to the institution in August. Dr. Spedding was formerly connected with the University of California.

Mr. Walter Stilwell, who is working towards his Ph.D. degree in the University of California, spent part of a day here in July.

Mr. S. T. Parker, a graduate of the University of B.C. who has been teaching in the northern part of the Province, has been granted a teaching Fellowship at Brown University, R.I., and left late in August to take up his new duties. Mr. Parker spent a week with us familiarizing himself with observatory technique.

Mr. Jack Fox of this city, who obtained his M.A. this year from the University of Saskatchewan, has secured a Fellowship at Princeton University. He plans to proceed to his doctor's degree. He will have a certain amount of astronomical work in which he will have the benefit of a month's experience gained here while in a voluntary capacity.

Mr. J. H. Labbe, librarian at the Dominion Observatory, Ottawa, spent half a day here renewing his acquaintance with the director and looking over the institution, as it was his first visit.

Your scribe addressed the Vancouver Centre of the R.A.S.C. on 12th October on "Novae" and gave a talk to the science student body on the following day on "Modern Ideas of the Universe". Dr.

J. A. Pearce is to address the Vancouver Institute on the 22nd on "Surveying the Universe".

Visitors to the observatory in August numbered 7,902 and in September 2,945.

W. E. H.

AMBROSE SWASEY.

In the October number of *Popular Astronomy* is a sketch of the life of Ambrose Swasey, who was born December 19, 1846, and died June 15, 1937. The author is Professor J. J. Nassau and he has performed his task with particular understanding and charm. A brief account of the life of Worcester R. Warner (b. May 16, 1846; d. June 25, 1929) was published in this JOURNAL in January, 1930.

Swasey's father was a successful farmer living near Exeter, N.H., and he was the ninth of ten children. In 1865 he became an apprentice in a machine shop and there met Warner. They became partners in 1869. They achieved fame and fortune by their production of machine tools of superior quality, but they obtained special distinction from their telescope mountings. The first one of moderate size was for a 9½-inch refractor for Beloit College. Then followed the Lick. On December 31, 1887, Alvan Clark placed his 36-inch lens in the tube which had been erected on Mount Hamilton. After this came the Yerkes telescope and many others.

Professor Nassau quotes a number of recorded sayings of Mr. Swasey and I take the liberty of reprinting some of them here:

> Although all my brothers and sisters went to academies or colleges, my only schooling came from the little county grammar school and lasted only two or three months.
>
> * * * *
>
> You know, it wasn't so very long ago since Galileo was put into prison for saying that the world was round and that the sun was the centre of the Universe. That was not so very long before my time, only 125 years before the birth of my grandfather whom I remember well. People now do not know much more than they did then.
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> * * * *

Referring to his friends J. A. Brashear, Alvan Clark, Simon Newcomb, Asaph Hall, E. C. Pickering, C. A. Young, J. E. Keeler, S. W. Burnham, and E. E. Barnard, he said:

> These men stand out as first magnitude stars in the realm of astronomical

science and to have had some part in their great work for science and humanity is indeed glory enough and compensation enough.

* * * *

W. H. Crocker: Why, Mr. Swasey, you are an astronomer.

Mr. Swasey: When I was a boy, my father kept a great number of sheep and, when working around the barn and with the sheep, some of the wool rubbed off on me, but that didn't make a sheep of me. In later years, I have been working with scientists and astronomers and rubbing against them, but it takes more than that to make an astronomer.

* * * *

Question in May, 1937: What in your opinion is the greatest thing you have done?

Answer: The highest type of construction and piece of work I ever did was the dividing engine. When you can take a spindle 4 inches in diameter and about 25 inches long with 5/8-inch taper to the foot and make that spindle fit into a bearing easily, and when you drop it 1/1000-inch it goes hard, you are getting down to a refinement about which we knew nothing in those times. Dividing engines had all failed in making the spindle—could not get a spindle in the bearing which would fit.

* * * *

They call this the age of metals and machinery, but the time will never come when the world will not need fine men even more than it needs fine machinery.

* * * *

Whatever success I have had, which enabled me to make these gifts [to engineering, education, the Baptist Church] I owe not to myself but to the fact that I have had a good mother, a good wife and a good partner in business.

A Round Trip to the Moon

Last winter when in Florida the present writer drove southward along the west coast of the peninsula. The trip began at Fort Myers where, in a profusion of beautiful trees and shrubs one sees magnificent avenues of Ryoal palms, probably the finest in the world. In 1884 Edison bought twenty acres of land here and erected a house which was shipped there in sections. Some years later Henry Ford acquired a winter home next to him. Fifteen miles farther south is a village named Estero, where is located a religious body known as the Koreshan Unity. Some information regarding this organization came to me about twenty years ago when a friend sent me a copy of their publication, *The Flaming Sword*. The sect was founded by Cyrus R. Teed, a physician who was born at Utica in 1839. Now

Cyrus is the Latin form of the Greek *Kuros*, which in Hebrew is *Koresh* and means the "Messiah". Teed was the new messiah. Settlements were established in Chicago in 1886 and at Estero in 1894, to which place the former settlement was transferred in 1903.

A few miles south of Estero is the Naples Beach, and here Teed (it is stated), using a new geodetic instrument which he had devised, made some measurements of the curvature of the earth's surface. He reached the extraordinary conclusion that the surface is concave, not convex, and that we live on the inner surface of a sphere 8,000 miles in diameter.

My interest in this matter was recalled a short time ago, when I received from my friend the Montreal amateur astronomer, Mr. John Forbes, some literature, which had come into his hands, dealing with a proposed trip to the moon by aeroplane, the possibility of which is based on Teed's fantastic views. The author of the circular describing the proposed trip is apparently a bright New Jersey man, who gives "illustrated talks on timely topics" to "women's clubs, student assemblies, technical organizations, etc.,"—for a consideration, of course. He argues that the earth being a hollow sphere of the size above stated, the moon is only 4,000 miles away instead of 240,000; and with a conceivable speed of 800 miles per hour the entire round trip of 8,000 miles might be approximately ten hours! He says, "We realize that it seems rather bold and too-good-to-be-true, but the more it is checked, *in an unbiassed attitude*, the more reasonable and feasible it becomes." What says the Interplanetary Society? And—what next?

Death of Lord Rutherford

The death of Lord Rutherford on October 19, following an operation, is a great loss to British science. He was born in New Zealand on August 30, 1871. He had a university training in his native land and then went to the Cavendish Laboratory, Cambridge, to engage in research under the world-famous J. J. Thomson. He made investigations on electric waves and when radio-activity was discovered by Becquerel in 1896 he attacked that subject and continued ever afterwards in this work. He was generally recognized as the world's greatest authority on radio-activity and the nature of the atom.

May 6.—Mr. J. A. McLean read a paper on "Time". He recalled the story of man's increasingly accurate attempts to measure time and to construct a satisfactory calendar. He described briefly various types of sundials, clepsdra and early clocks, and the modern improvements due to the discovery of the pendulum and the balance-wheel. The differences between sidereal time, true solar time and mean solar time, the standard time zones, and the methods of sending out very accurate observatory time-signals were dealt with by the speaker.

May 15.—A picnic, attended by about 15 members, was held near Mr. Wates's telescope on the north bank of the Saskatchewan River. After supper the sky cleared and the seeing was good. The members observed a number of objects through the 6½-inch reflector, including the moon, Saturn, Mars, and some clusters and double stars.

Afterwards the party adjourned to Mr. Wates's house for coffee.

E. S. Keeping, *Hon. Secretary.*

AT TORONTO

October 12, 1937.—The first meeting of the Toronto Centre, for the term 1937-38, was held at the David Dunlap Observatory, Richmond Hill, at the invitation of the Director, Dr. R. K. Young. The members met in the lecture hall. Mr. E. J. A. Kennedy presided.

Dr. R. K. Young gave a short address explaining the researches carried out at the observatory, its main programme being the determination of radical velocities. 2,400 spectra stars have been secured in the last two years, and it is hoped that next year will see completed the necessary set of four plates for each star in the programme. Dr. Young also mentioned Mrs. Hogg's work on variable stars, Dr. Heard's on binaries, and Dr. Millman's on meteors.

The members were then allowed to roam about the buildings, and look through the instruments. Dr. Hogg was in charge of the 74-inch, the Ring Nebula in Lyra and the planet Saturn being the objects shown. Dr. Heard and Mr. D. A. MacRae manned the 19-inch and showed the Moon and Saturn. In the computing room two transparencies were on display, one, made from a photograph taken with the 19-inch, of the Ring Nebula in Lyra, and the other from two spectra taken with the 74-inch. The measuring machines were set up, as when in use, to show the method used in measuring plates for radical velocities.

Refreshments in the typical R.A.S.C. manner terminated a most delightful evening.

F. Shirley Patterson, *Recorder.*

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